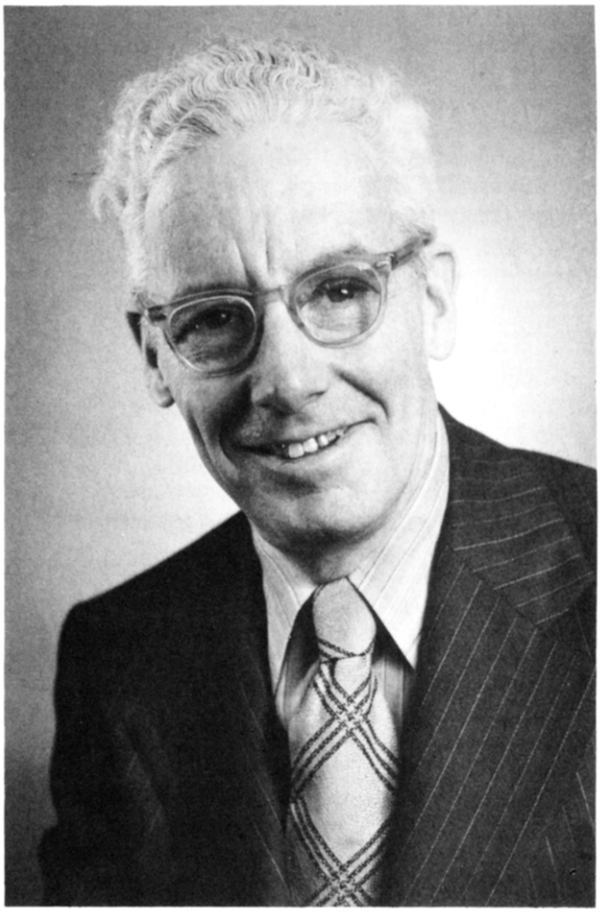

# Herbert Morawetz: A Man of Ideas

As Herbert Morawetz approaches his 70th birthday, many of his friends look back over Herbert's career and note his numerous and diverse accomplishments. They point to his long interest in polymer–polymer association processes in solution, going back to his first paper on the subject with Gobran in 1954 and continuing up to his recent use of fluorescent dyes to study the kinetics of the association process. Equally important, they say, is the result of his efforts on polyelectrolyte behavior in solution. This work began under the influence of his Ph.D. supervisor, Turner Alfrey, Jr., at the Polytechnic Institute of Brooklyn (now the Polytechnic Institute of New York), and by 1960 he had already published 30 papers on the subject.

Herbert himself emphasizes the aspects of this work which describe the kinetics of reactions in systems containing polymers. Early studies examined neighboring group effects on reactivity and introduced the term "microtacticity" to explain kinetic dependence upon backbone stereochemistry. These were followed by an important series of papers on polyelectrolyte catalysis of ionic reactions. The most fascinating of these describes the quenching of $UO_2^{2+}$ fluorescence by $Fe^{2+}$ in solutions of poly(vinylsulfonic acid), a system showing enhanced fluorescence at high quencher concentrations. This brief excursion into fluorescence spectroscopy would soon become a major direction in his research.

Herbert Morawetz has spent his entire academic career at PINY. During the 1950s and early 1960s the Polytechnic Institute of Brooklyn had a remarkable chemistry faculty. Aside from Herbert and Herman Mark, founder of the Polymer Institute, there were, among others, Frederick Eirich, Isidor Fankuchen, Murray Goodman, Rudolph Marcus, Robert Mesrobian, Gerald Oster, Charles Overberger, and Robert Ullman. Those were heady days, when polymer science seemed to enter a new era under the influence of new theory and new techniques, particularly those based upon spectroscopy.

During his youth, Herbert was very much under the influence of his father. The family, through three generations, had a textile plant in Prague, Czechoslovakia, until the German invasion in 1938. Family life was rich in theatre and literature. His father, Richard, traveled widely, visiting India, China, Japan, and the U.S. in the early days of this century, and assembled, among other things, an exquisite collection of butterflies from Ceylon and his photographs of the orient that Herbert still talks about. These did not survive the war, but his father's collection of Czech literary manuscripts is now a part of a museum collection in Prague. After leaving Czechoslovakia, the family settled in Toronto. Herbert's brother Oskar, now retired from the music faculty at the University of Toronto, is considered to be among Canada's best known composers.

We are fortunate beneficiaries of this cultural tradition. In its literary form it has given us not only "Macromolecules in Solution", first published in 1965 and revised in 1978, an excellent introduction to the topic, but just this year Herbert's "Polymers, The Origins and Growth of a Science" was published. It is a beautifully written history of ideas leading from the first concepts of bonding in simple molecules to modern (1960s) ideas of synthesis, structure, shape, and performance of macromolecules.

Herbert Morawetz entered the family business after completing his gymnasium education in 1935. Like his father before him, he was, as a lad of 20, sent abroad to learn aspects of the textile trade. Herbert spent a month in London picking up English and the rest of the year in Northern Ireland as an observer at a factory that manufactured the machinery used in Prague. He returned home in 1936. There he worked in the textile business until the decision was made for the Morawetz family to emigrate to Canada.

In December 1939, halfway through the term and speaking poor English, Herbert arrived at the University of Toronto and sought admission to study chemistry. Turned down by the chairman of the Chemistry Department, Herbert found Chemical Engineering to be more sympathetic. He was admitted, and 4 months later he wrote final exams for the year. "It was a real struggle", he explained to me, but our records show that he got an overall mark of B that year and maintained an A average thereafter. Herbert graduated with a B.A.Sc. degree in 1943. After a summer making picrite (nitroguanidine) explosive at the Welland Chemical Works under the direction of Peter MacBride, he returned to obtain an M.A.Sc. degree with M. C. Boswell at Toronto.

In 1945 he moved to the U.S. where he worked until 1949 as a research chemist for the Bakelite Co. He received a Ph.D. in Chemistry at the Polytechnic Institute of Brooklyn in 1950 and spent the year 1950–1951 at the Harvard Medical School on a Fellowship from the National Institutes of Health. In 1951 he came as Assistant Professor to the Polytechnic Institute, where he was promoted to Associate Professor in 1953 and to Professor in 1958. In 1971 he became Director of the Polymer Research Institute and in 1981 he was made Institute Professor at PINY.

In 1956, he spent 6 months at the Weizmann Institute in Rehovot, Israel, on a Louis Lipsky Exchange Fellowship. In 1966, he was awarded a Special Fellowship of the Na-

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tional Institutes of Health for a year to be spent at the Institute of Physical Chemistry at the University of Naples. Next year in April he will receive the ACS Award in Polymer Chemisty.

As a scientist Herbert Morawetz is a purist, with a love of knowledge, truth, and insight. Toward younger scientists, particularly newcomers to the polymer field, he has shown exceptional patience and understanding; but this patience does not extend to sloppy thinking. One of his former graduate students once referred to him as "genial but tough".

The most controversial subject in which Herbert Morawetz was involved concerned the radiation-induced solid-state polymerization of crystalline monomers. Invited in 1953 by G. J. Dienes of the Brookhaven National Laboratories to join a group to explore the possible use of the radioactive products of nuclear fission in polymer science, he began a program (initially in collaboration with R. B. Mesrobian) on the use of ionizing radiation for initiating graft polymerization and for polymerizing crystalline monomers. It was difficult at that time to accept the idea that organic chemical reactions might occur in the solid state. Alternative hypotheses suggested that reaction exothermicity would lead to a fluid interphase between monomer and polymer where the actual reaction would occur. A variety of clever experiments by the Morawetz group established the solid-state nature of the reaction and led to the idea that the geometric order of the crystalline reagent might be utilized to impose a preferred direction on the chain propagation.

In the early 1970s he published a series of papers dealing with polymer cyclization. The first paper, with Goodman, reminded many scientists of the early experiments by Stoll and stimulated more than a decade of effort by others on cyclization processes. The scientific contribution of these papers lies in their discussion of excluded volume effects on polymer reactions and in the development of chemical kinetics as a tool for studying polymer conformation.

Growing out of this work was the idea that reaction kinetics might be a useful means of testing whether internal rotation in polymers was crankshaft-like. The crankshaft picture arises from the hypothesis that frictional drag would be minimized by highly correlated localized motion in which rotations about two bonds traversed their energy maxima in synchrony. Such a process would have a higher activation energy than a corresponding one-bond rotation in a small molecule. Various experiments involving thermal and photochemical azobenzene isomerization, and, more recently, intramolecular excimer formation, show that activation energies for the small molecule and polymer processes are comparable and at odds with the simple crankshaft idea.

If one research topic were to be identified with the modern-day Herbert Morawetz, it would be the use of fluorescence spectroscopy to study the properties of polymer systems. What stands out in this work is the variety of scientific problems in the polymer field which are amenable to study by this technique, from local conformational transitions to characterizing polymer compatibility. His 1979 review in *Science* served to alert much of the polymer community to the existence of fluorescence spectroscopy. But it has been his more recent work on blends and on diffusion processes in the melt which have demonstrated the power of a good idea and a rather straightforward technique.

There is one further aspect of Herbert Morawetz's career that deserves special note. Since his early days as a scientist, Herbert has been a champion of the idea that biopolymers and synthetic polymers form parts of a common field. Both areas have become so large that scientists tend to specialize and to acquire a label. Herbert has as a matter of pride and conviction tried to bridge that gap, in his books, in some of his research topics, and in the meeting he organized in 1980 for the New York Academy of Sciences on "Luminescence from Biological and Synthetic Macromolecules". It is fitting that I end this tribute with a comment from a well-known biologist. This man once told me that although he never met Herbert Morawetz, he reads his papers whenever he can. Herbert Morawetz's papers, he explained, always contain a new idea.

His friends all join me in wishing him the happiest of birthdays this October 16 and a long and fruitful continuation of his career.

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